

The Effects of Blockchain Technology on Accounting Information Systems in Free Zones (FTZ): A Systematic Review of Architectural and Functional Transformation

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تأثير تقنية سلسلة الكتل (البلوك تشين) على نظم المعلومات المحاسبية في المناطق الحرة: مراجعة منهجية للتحويل المعماري والوظيفي

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Received: April 25, 2026

Accepted: May 25, 2026

Published: June 14, 2026



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Abstract:

The operational environment of Free Trade Zones (FTZs) is characterized by high-volume, complex cross-border transactions, and stringent demands for verifiable data integrity and customs compliance. Conventional, centralized Accounting Information Systems (AIS) are demonstrably suboptimal for this environment, constrained by retrospective reconciliation procedures, transactional latency, and systemic vulnerability to data manipulation.

This Systematic Literature Review (SLR) investigates the foundational impact of Distributed Ledger Technology (DLT), specifically Blockchain Technology (BC), on the architectural structure and functional mechanics of the AIS within the FTZ context. BC facilitates the essential paradigm shift from a private data store to a decentralized, self-verifying evidence platform, replacing traditional reliance on human intermediaries with cryptographic trust. The change is thoroughly examined using three integrated architectural pillars of BC: Triple-Entry Accounting (TEA), Smart Contracts (SC), and Immutability.

Keywords: Blockchain Technology, Accounting Information Systems, Free Zones

المخلص:

تتسم بيئة العمل في المناطق الحرة بكثافة المعاملات العابرة للحدود وتعقيدها، فضلاً عن المتطلبات الصارمة لضمان سلامة البيانات القابلة للتحقق والامتثال الجمركي. وتعد أنظمة المعلومات المحاسبية المركزية التقليدية غير مثالية لهذه البيئة، إذ تعاني من قيود تتمثل في إجراءات المطابقة بأثر رجعي، وتأخر المعاملات، وضعفها أمام التلاعب بالبيانات.

تبحث هذه المراجعة المنهجية للأدبيات الأثر الجوهري لتقنية السجلات الموزعة، وتحديدًا تقنية سلسلة الكتل، على البنية المعمارية والآليات الوظيفية لأنظمة المعلومات المحاسبية في سياق المناطق الحرة. تُسهّل سلسلة الكتل التحوّل النموذجي الأساسي من مخزن بيانات خاص إلى منصة أدلة لامركزية ذاتية التحقق، مستبدلةً الاعتماد التقليدي على الوسطاء البشريين بالثقة المشفرة. ويتم فحص هذا التغيير بدقة باستخدام ثلاثة أركان معمارية متكاملة لسلسلة الكتل: المحاسبة ثلاثية القيد، والعقود الذكية، وعدم قابلية التغيير.

الكلمات المفتاحية: تقنية سلسلة الكتل، نظم المعلومات المحاسبية، المناطق الحرة

Introduction

landscape of Free Trade Zones (FTZs) is defined by substantial, intricate cross-border transactions and rigorous requirements for demonstrable data integrity and customs adherence (Atadoga et al., 2024; Eyo-Udo et al., 2025; Oraby, 2025). Conventional, centralized Accounting Information Systems (AIS) are clearly not the best choice for this context because they have problems with retrospective reconciliation, transactional slowness, and a system that is open to data manipulation (AlSaqqa et al., 2019; Fullana & Ruiz, 2019; Kolisnyk et al., 2023). This Systematic Literature Review (SLR) examines the fundamental influence of Distributed Ledger Technology (DLT), particularly Blockchain Technology (BC), on the architectural framework and operational dynamics of the AIS in the context of Free Trade Zones (FTZ). BC facilitates a crucial paradigm change from a proprietary data store to a decentralized, self-verifying evidence platform, supplanting the conventional dependence on human intermediaries with cryptographic trust (Alikhani & Ataei, 2025; Dai & Vasarhelyi, 2017; Ahmed, 2024). Three integrated architectural pillars of BC—Triple-Entry Accounting (TEA), Smart Contracts (SC), and Immutability—are used to rigorously assess the transition (Chaudhary, 2022; Kuhn, 2018; Pugna & Du, 2020).

2. Methodology and Review Protocol (SLR Protocol)

To evaluate the findings and assure the scientific integrity and replicability required of academic research, this study uses a strong Systematic Literature Review (SLR) technique. Utilize recognized protocols for theme analysis and systematic evidence synthesis (Bellucci et al., 2022; Nofel et al., 2024; Secinaro et al., 2023).

A. Research Questions and Scope Definition

This review is guided by three targeted research topics, aimed to limit the analysis completely to the architectural and functional interaction between BC and AIS in high-scrutiny situations such as FTZs (Qolby & Dwirini, 2024; Atik & Kelten, 2021; Hoang et al., 2023; Oraby, 2025).

1. FTZ AIS Transformation (RQ1): How does Blockchain architecture (TEA and Immutability) fundamentally alter the core structure and data reliability of the AIS, and what impact does this have on achieving Representational Faithfulness in FTZ records? (Chen, 2025; McCallig et al., 2019; Qolby & Dwirini, 2024; Hoang et al., 2023; Marselita, 2024).
2. Functional Automation (RQ2): How can integrating Smart Contracts into the FTZ AIS transaction cycle increase functionality and internal controls, especially for complex fiscal rules? Jiang (2024); Gad and Moawad (2021); Alnaimat et al. (2025); and Iriyadi et al. (2023).
3. Architectural viability (RQ3): What are the essential internal limitations (e.g., scalability, secrecy) and cryptographic architectural solutions required for large-scale, safe BC-AIS deployment in free trade zones? Chaudhary (2022); Zhong et al. (2023); Baba et al. (2025); Atadoga et al. (2024); and Putritama et al. (2024)..

B. The Literature Identification and Filtering Process

The first literature corpus was found through exhaustive searches in major academic indexing databases (e.g., Scopus, Web of Science), taking into account the large rise in research since 2016 (Atik & Kelten, 2021; Putritama et al., 2024; Horodyskyi et al., 2024). The filtering technique included abstract screening and full-text evaluation.

1. Data Sources & Search Strategy

The original literature corpus was compiled using systematic searches of major academic indexing databases, principally Scopus and Web of Science (WoS) (Secinaro et al., 2023; Nofel et al., 2024; Putritama et al., 2024). This strategy ensures the inclusion of high-quality, peer-reviewed articles and conference proceedings, reflecting the interdisciplinary nature of accounting, business, and computer science research (Secinaro et al., 2023; Atik & Kelten, 2021). The search period reflected the considerable quadratic growth in research interest in BC and AIS found between 2016 and 2017 (Putritama et al., 2024; Horodyskyi et al., 2024; Han et al., 2023). The search strategy utilized keywords strictly related to the research scope, including: "Blockchain," "Distributed Ledger Technology," "Accounting Information Systems," "Triple-Entry Accounting," "Smart Contracts," and "Immutability" (Putritama et al., 2024; Han et al., 2023).[1, 1]

2. Academic Inclusion and Exclusion Criteria

A stringent set of academic criteria was applied during the abstract and full-text screening to ensure that the retrieved literature focused precisely on the architectural and functional mechanics of the integrated BC-AIS system (Secinaro et al., 2023; Bellucci et al., 2022). The justification for the exclusion criteria is essential to maintain the SLR's focus on the technical transformation of the AIS, rather than peripheral topics (Fullana & Ruiz, 2019).

C. Academic Inclusion and Exclusion Criteria

A stringent set of academic criteria was applied during the filtering process to ensure that the retrieved literature focused precisely on the architectural and functional mechanics of the integrated BC-AIS system, excluding research focused on peripheral or non-technical applications (Secinaro et al., 2023; Bellucci et al., 2022; Nofel et al., 2024).

Table 1 Comparison of Inclusion Criteria and Exclusion Criteria

Inclusion Criteria (FTZ-AIS Focus)	Exclusion Criteria (Non-Relevant Themes)
Articles focusing on the architectural shift from Double-Entry to Triple-Entry Accounting (TEA) and the mechanics of the cryptographic receipt ("trebit") (Hoang et al., 2023; Hambiralovic & Karlsson, 2018; Qolby & Dwirini, 2024; Kuhn, 2018; Eyo-Udo et al., 2025).	Research focused purely on Cryptocurrency Valuation or Taxation (excluding analysis of the underlying DLT/ledger mechanisms) (Pravdiuk et al., 2024; Atik & Kelten, 2021; Han et al., 2023; Su et al., 2021).
Studies detailing the quantitative or qualitative functional impact of Smart Contracts on AIS operational efficiency and internal control quality (ICQ) (Gad & Moawad, 2021; Alnaimat et al., 2025; Jiang, 2024; Iriyadi et al., 2023).	Studies detailing General Legal Theory, generalized adoption models (e.g., UTAUT), or external auditing procedures (e.g., audit opinions) without analyzing the technical transformation of the AIS data output or controls (Sofyani et al., 2024; Gidwani, n.d.; Kuhn, 2018; Oraby, 2025)
Literature analyzing technical solutions (e.g., MPC, HE) for maintaining data confidentiality within a distributed ledger architecture (CPA) (Zhong et al., 2023; Chaudhary, 2022; McCallig et al., 2019; Ibrahim, 2023).	Articles focused solely on IoT/AI/ML as a non-accounting device or government policy development without specific links to AIS architecture or function (Nofel et al., 2024; Kanaparathi, 2023).

D. Data Analysis and Thematic Classification

The final corpus of literature was subjected to Thematic Analysis and Coding methodology, which organized the findings around four structural criteria critical to the FTZ context: TEA and Reliability, Smart Contract Automation, Immutability and Data Integrity, and Architectural Constraints (Secinaro et al., 2023; Fullana & Ruiz, 2019; Atadoga et al., 2024).

The findings were carefully arranged and addressed around the four predetermined structural criteria crucial to the FTZ context: TEA and Reliability, Smart Contract Automation, Immutability and Data Integrity, and Architectural Constrains. (Fullana and Ruiz, 2019; Han et al., 2023).

3. Foundational architectural transformation: Triple-Entry Accounting (TEA)

The most major architectural effect of BC integration is the transition to TEA, which establishes a self-verifying, multilateral ledger structure necessary for high-assurance FTZ documentation. (Baba et al., 2025; Putritama et al., 2024; Adnan et al., 2024; Hoang et al., 2023).

A. TEA: The Transition from Centralised to Cryptographic Ledgers

TEA fundamentally shifts the FTZ AIS away from proprietary, centralized ledgers by incorporating a cryptographically sealed third entry, the "trebit" or verification receipt, alongside the traditional debit/credit entries (Qolby & Dwirini, 2024; Hambiralovic & Karlsson, 2018; Eyo-Udo et al., 2025; Kuhn, 2018; Pugna & Duțescu, 2020). This receipt serves as an irreversible, network-validated link that legally binds the transacting parties, establishing a distributed and shared accounting architecture (Abubakar and Abubakar, 2023; Al-Shmam & Riyadh, 2024; Dai & Vasarhelyi, 2017).

- TEA reduces reconciliation lag, a key functional influence on the FTZ AIS (Fullana & Ruiz, 2019; Putritama et al., 2024; Yusuf et al., 2025; Alikhani & Ateai, 2025; Adnan et al., 2024; Adelowotan & Coetsee, 2021). The third entry is a mathematically assured mutual receipt recorded synchronously across all ledgers, rendering post-transaction verification processes operationally redundant (Baba et al., 2025; Atadoga et al., 2024; Alnaimat et al., 2025).

- The shared TEA ledger delivers reliable and transparent accounting information through irrefutable digital proof (Marselita, 2024; Ahmed, 2024; Eyo-Udo et al., 2025; Oraby, 2025). This strengthens the AIS's intrinsic integrity and directly supports the accounting concept of Representational Faithfulness, which is essential for rigorous customs reporting (Qolby & Dwirini, 2024; Hoang et al., 2023; McCallig et al., 2019; Chen, 2025).

The FTZ ledger's security and dependability are improved by immutability, which is attained through cryptographic hash-linking of blocks and consensus protocols. This ensures that once data is recorded, the record is permanent and irreversible (Chaudhary, 2022; Su et al., 2021; Atadoga et al., 2024; Abubakar & Abubakar, 2023; Kolisnyk et al., 2023). The possibility of fraud or mistakes that come with centralized data storage is eliminated by this feature (AlJboul, 2024; Kanaparathi, 2023; Al-Shmam & Riyadh, 2024; Chen, 2025).

- Continuous Data Assurance: Continuous Accounting (CA) and real-time reporting capabilities are made possible by the AIS's permanent record of sequential asset status changes, which is essential for FTZ inventory

monitoring (Alikhani & Ataei, 2025; Han et al., 2023; Oraby, 2025). This is essential for tracking changing customs obligations and offers continuous data for assurance (AlSaqa et al., 2019; Nofel et al., 2024).

- **System Resilience:** If any one node's data is corrupted, the remaining network automatically synchronizes and fixes the damaged ledger instance thanks to architectural redundancy (ledger duplication across decentralized nodes), ensuring continuous access to transactional truth (AlSaqa et al., 2019; Nofel et al., 2024; Chen, 2025; Eyo-Udo et al., 2025).

4. Functional Automation: Internal Control Quality and Smart Contracts (SC) By integrating operational rules into the system's code, Smart Contracts (SCs) offer the non-discretionary engine required to enforce intricate FTZ-specific business logic, hence improving the quality of internal controls (Alikhani & Ataei, 2025; Pugna & Du •escu, 2020; Fullana & Ruiz, 2019).

A. SCs as Automated Internal Controls for FTZ Compliance

SCs are programmable algorithms that replace manual administrative activities by automating execution when predetermined circumstances are met (Alikhani & Ataei, 2025; Pugna & Du •escu, 2020; Iriyadi et al., 2023; Eyo-Udo et al., 2025). By integrating specific fiscal and compliance logic directly into the execution layer, SCs serve as automatic internal controls within the required permission BC environment for FTZs (Alnaimat et al., 2025; Fullana & Ruiz, 2019).

- **Non-Discretionary Execution and Fraud Mitigation:** By making unauthorized or out-of-sequence actions computationally impossible within the boundaries of the AIS, SCs enforce mandatory, automated compliance, systematically mitigating FTZ-specific fraud risks (e.g., deliberate misclassification of assets to evade duties) (Gad & Moawad, 2021; AlJboul, 2024; Al-Shmam & Riyadh, 2024; Chen, 2025).
- **Effect on Internal Control Quality (ICQ):** Internal control quality is greatly strengthened by this structural enforcement. According to a thorough quantitative analysis (Gad & Moawad, 2021; Al-Shmam & Riyadh, 2024; Eyo-Udo et al., 2025), BC adoption may explain about 96.6% of observed changes in internal control quality.

B. Measurable Gains in Accuracy and Efficiency

As demonstrated empirically in transactional data processing, the functional automation powered by SCs produces quantifiable operational benefits essential for FTZ competitiveness (Jiang, 2024; Alnaimat et al., 2025; Iriyadi et al., 2023; Adnan et al., 2024).

Table 2: Measurable Gains in Accuracy and Efficiency

Performance Metric	Quantifiable Improvement (Empirical Synthesis)	Functional Relevance to FTZ AIS
Information-Sharing Efficiency	Enhanced by 25.7% (Jiang, 2024; Alikhani & Ataei, 2025)	Direct acceleration of data flow, enabling Real-Time Accounting (RTA) and continuous reporting (Han et al., 2023; Alnaimat et al., 2025; Eyo-Udo et al., 2025).
Data Accuracy	Improved by 19.8% (Jiang, 2024; Alikhani & Ataei, 2025]	Significant reduction in human error, manual input risk, and manipulation attempts (Chen, 2025; Gad & Moawad, 2021; AlJboul, 2024; Al-Shmam & Riyadh, 2024)
Financial Information-Sharing Costs	Reduced by 13.6% (Jiang, 2024; Alikhani & Ataei, 2025)	Optimization of back-office operations by eliminating reconciliation and reducing intermediary reliance (Adelowotan & Coetsee, 2021; Alnaimat et al., 2025; Jiang, 2024)
Transaction Processing Time	Reduced from 48 hours to 5 hours (Alnaimat et al., 2025)	Crucial reduction in latency for high-speed FTZ transactions (Baba et al., 2025; Alnaimat et al., 2025; Kolisnyk et al., 2023; Eyo-Udo et al., 2025).
Operating Costs	Reduced by 15%–20% (Alnaimat et al., 2025)	Direct economic benefit from automation and reduced errors (Adelowotan & Coetsee, 2021; Kolisnyk et al., 2023; Alnaimat et al., 2025).

5. Architectural Viability: Limitations and Cryptographic Remedies

A. Architectural Mitigation (CPA) and the Confidentiality Paradox

The Confidentiality Paradox, which balances DLT's intrinsic transparency (required for regulatory proof) with businesses' need to safeguard proprietary trade secrets (such as unit costs and supplier data), is the fundamental

architectural conflict for FTZ adoption (Chaudhary, 2022; Ibrahim, 2023; Baba et al., 2025; Atik & Kelten, 2021; AlSaqqa et al., 2019; Chen, 2025).

For FTZ enterprise AIS, public blockchain models are essentially inappropriate (AlSaqqa et al., 2019; Atik & Kelten, 2021).

A complex Computational Privacy Architecture (CPA) must be integrated into a permissioned DLT framework in order to achieve the architectural solution (Zhong et al., 2023; Chaudhary, 2022; McCallig et al., 2019). • Multi-Party Secure Computing (MPC): MPC realizes the idea that "data availability is invisible" by enabling the AIS to carry out necessary complex financial calculations across multiple nodes without submitting the raw data in plain text (Zhong et al., 2023; McCallig et al., 2019; Ibrahim, 2023; Chen, 2025).

• Homomorphic Encryption (HE): HE ensures data confidentiality throughout the processing and analysis stages by enabling sophisticated accounting algorithms to operate directly on encrypted financial data (ciphertext) to produce the required aggregate financial information (Zhong et al., 2023; McCallig et al., 2019; Chen, 2025).

Since it is the only practical approach to concurrently meet the conflicting demands of business confidentiality (trade secrets) and regulatory transparency (Customs surveillance), the strict integration of CPA elements (MPC/HE) is an architectural precondition for FTZ adoption (Ibrahim, 2023; Zhong et al., 2023; Chaudhary, 2022).

B. Internal Architectural Restrictions: Integration, Cost, and Scalability

The dependable implementation of BC-AIS in FTZs is still hampered by a number of internal limitations pertaining to complexity and capacity, despite the obvious architectural benefits (Qolby & Dwirini, 2024; Atadoga et al., 2024; Baba et al., 2025; Putritama et al., 2024; Iriyadi et al., 2023).

1. Scalability and Performance: The most significant internal constraint remains scalability (Putritama et al., 2024; Baba et al., 2025; Chaudhary, 2022; Adnan et al., 2024)
1. The system's ability to manage the massive data volumes and high transaction throughput rates needed by large FTZ operations is challenged by the architectural features that enforce integrity (consensus protocols and redundancy), which raise processing complexity (Chaudhary, 2022; Baba et al., 2025; Kolisnyk et al., 2023). To preserve the functional benefit of real-time operation, latency problems must be resolved (Alnaimat et al., 2025; Baba et al., 2025; Kolisnyk et al., 2023; Eyo-Udo et al., 2025).
2. Integration and Technical Barriers: It is technically difficult, time-consuming, and expensive to establish infrastructure and systems in order to smoothly integrate a BC layer with current legacy AIS and ERP systems. (Alikhani & Ataei, 2025; Qolby & Dwirini, 2024; Kolisnyk et al., 2023; Iriyadi et al., 2023; Atadoga et al., 2024). (Alikhani & Ataei, 2025; Qolby & Dwirini, 2024; Kolisnyk et al., 2023; Iriyadi et al., 2023; Atadoga et al., 2024). According to the consensus, BC will be implemented as a specialized, integrated layer within a hybrid system that coexists with current ERP systems. As a crucial internal functional requirement, seamless interoperability standards must be met (Kuhn, 2018; Nofel et al., 2024; Alnaimat et al., 2025; Horodyskyi et al., 2024).
3. Competency Barrier: Adequate professional training and the accountant's IT proficiency are critical for successful implementation (Giang & Tam, 2023; Alikhani & Ataei, 2025; Su et al., 2021; Kuhn, 2018; Eyo-Udo et al., 2025). Traditional data entry must give way to algorithmic management, DLT understanding, and Smart Contract code interpretation (Al-Shmam & Riyadh, 2024; Gidwani, n.d.).

6. Discussion and Strategic Trajectories for FTZ-AIS

By institutionalizing TEA, automating compliance through SCs, and offering immutable records, Blockchain technology creates a system that generates verified, instantaneously reconciled data by directly integrating trust into the system's foundation. The systematic review confirms that Blockchain technology delivers a fundamental and quantifiable architectural transformation to the FTZ AIS (Dai & Vasarhelyi, 2017; Ahmed, 2024; Al-Shmam & Riyadh, 2024).

A. The Unavoidable Requirement for CPA in FTZ Situations

The Computational Privacy Architecture (CPA) is not just an option but an existential necessity due to the high-stakes regulatory and competitive character of FTZs (Chaudhary, 2022; Ibrahim, 2023; Zhong et al., 2023). The review emphasizes how DLT's inherent transparency, while perfect for removing fraud and agency risk (AlJboul, 2024; Gad & Moawad, 2021), directly jeopardizes the survival of competitive FTZ businesses by disclosing confidential information (Baba et al., 2025; Atik & Kelten, 2021). Therefore, the only pragmatic solution is the mandatory use of technologies like MPC and HE. These techniques balance the requirement for regulatory compliance with commercial confidentiality by enabling customs authorities to confirm the mathematical accuracy of declarations (such as duty calculations) without having access to commercially sensitive data (such as unit pricing, supplier identity) (McCallig et al., 2019; Chen, 2025). Permissioned Consortium BCs must be given a lot of weight in the architectural decision in order to guarantee governance and restricted access that are specific to the zone's business and regulatory needs (AlSaqqa et al., 2019).

B. Strategic Automation and Cost-Effective Realization

The transition to SC-driven execution allows FTZ AIS to realize considerable cost reductions and efficiency advantages (Alnaimat et al., 2025). The reported functional gains, such as a 25.7% increase in information-sharing

efficiency and a 13.6% cost reduction, are directly attributed to the removal of TEA's redundant, manual reconciliation stages (Jiang, 2024; Alikhani & Ataei, 2025). Reducing processing time from 48 hours to 5 hours is a crucial competitive advantage for an FTZ, as transactional latency affects logistics speed (Alnaimat et al., 2025; Kolisnyk et al., 2023). The ability of SCs to implement complicated fiscal laws with 96.6% assurance of internal control quality significantly reduces the high risks of fraud and fines associated with customs zones (Gad & Moawad, 2021).

C. Using Hybrid Models to Overcome Integration and Scalability Issues

Scalability constraints and the high cost/complexity of integrating with monolithic Enterprise Resource Planning (ERP) systems are the two main internal obstacles to broad BC adoption (Baba et al., 2025; Atadoga et al., 2024). According to the study, the Hybrid System is the most practical deployment method for FTZs (Kuhn, 2018; Nofel et al., 2024). In order to enable the current ERP infrastructure to manage high-volume processing while taking use of BC's trust characteristics, this technique promotes integrating BC as a secure data layer that only saves the cryptographic TEA receipts. To solve the latency issue and guarantee the smooth transfer of data between the legacy and DLT layers, future investment must concentrate on creating strong interoperability standards and high-performance BC algorithms created especially for enterprise throughput (Horodyskyi et al., 2024; Atadoga et al., 2024).

D. Policy Suggestions for FTZ Authorities

FTZs must give strategic architectural development top priority in the following areas if they hope to preserve regulatory excellence and competitiveness:

1. **Require Advanced CPA Integration:** A Permissioned Consortium BC integrated with CPA elements (MPC/HE) must be used for architectural deployment. In order to make the system workable for competitive FTZ businesses, it is vital to balance the conflicting demands of corporate secrecy (trade secrets) and regulatory transparency (customs surveillance) (Zhong et al., 2023; Chaudhary, 2022; Ibrahim, 2023; McCallig et al., 2019).
2. **Standardize SC Compliance Logic:** Create standardized Smart Contract repositories that encapsulate regulatory adherence logic and FTZ-specific duty/tax regulations. By utilizing the SC's capacity to offer improved internal control quality, this ensures non-discretionary compliance across all tenant systems (Gad & Moawad, 2021; Alnaimat et al., 2025; Al-Shmam & Riyadh, 2024).
3. **Invest in Scalability and Interoperability:** Future funding should go toward creating reliable hybrid system integration frameworks and high-performance BC algorithms. Internal limitations are addressed, guaranteeing that the DLT layer can manage FTZ transaction volumes without experiencing intolerable latency and preserving smooth data transmission with current legacy ERP systems (Baba et al., 2025; Kuhn, 2018; Nofel et al., 2024; Atadoga et al., 2024).

Conclusion

Blockchain presents an entirely new AIS paradigm based on automation, cryptographic assurance, and verification. Blockchain's appropriateness for FTZ situations, where dependability, traceability, and speed are crucial, is confirmed by an expanded literature synthesis. However, resolving issues with scalability, secrecy, and integration as well as building solid professional competences are essential for successful adoption. The systematic research shows that by integrating trust through triple-entry accounting, smart contract automation, and immutable data, blockchain technology offers a revolutionary paradigm for Free Trade Zone Accounting Information Systems (FTZ AIS). Together, these characteristics improve operational effectiveness and representational authenticity, lowering reconciliation costs and lowering the risk of fraud (Dai & Vasarhelyi, 2017; Gad & Moawad, 2021; Alnaimat, Chumak, Artemchuk, Khmeliuk, & Skrypnyk, 2025). However, the persistent problems of scalability and the confidentiality paradox continue to be major obstacles to enterprise-scale adoption, despite empirical evidence showing significant improvements—such as a ~25.7% increase in information-sharing efficiency and a reduction in processing latency from 48 hours to 5 hours (Putritama, Warsono, Ali, & Handayani, 2024; Baba, Neupane, Wu, & Yaroh, 2025). Permissioned consortium blockchains combined with computational privacy architectures (such as multi-party computation and homomorphic encryption) are not only technological advancements in FTZ contexts, but also necessary to balance corporate confidentiality with regulatory transparency (Chaudhary, 2022; Zhong, Du, Huang, & Qian, 2023).

Blockchain is not a cure-all, despite its potential. Strong governance and hybrid deployment models—blockchain as the trusted receipt layer and ERP as the high-volume processing layer—are necessary because transparency that improves auditability may inadvertently reveal competitive information (Horodyskyi, Hrabchuk, Berezhnyi, Fedorova, & Iefremov, 2024; Kuhn, 2018). Future research will focus on high-performance algorithms and standardized smart-contract repositories for FTZ-specific compliance rules. The cost-benefit of smart-contract-driven automation must be evaluated against implementation complexity and throughput limits (Alnaimat et al., 2025; Gad & Moawad, 2021). All things considered, blockchain's place in FTZ AIS is strategically feasible, but it necessitates a well-rounded strategy that balances innovation with privacy, interoperability, and legal compliance.

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